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Revisit of the dual BEM for crack problems using SVD updating technique

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The boundary element method (BEM) is easier than the finite element method (FEM) on the viewpoint of the discretization of one dimension reduction rather than the domain discretization of finite element method. The disadvantage of BEM is the rank deficiency in the influence matrix, which do not occur in the FEM. The dual BEM is used to ensure a unique solution for the problem containing a degenerate boundary by combining the singular and hypersingular equations. Following the successful experience on the retrieval of information using singular value decomposition (SVD) updating term and updating document, this technique is also used to extract out the informations in the dual BEM. Finally, a cracked bar under torsion was demonstrated to see the mathematical SVD structure of four influence matrices in the dual BEM.

Keywords: *degenerate boundary, dual BEM, crack problems, SVD updating technique.*

1 Introduction

Mathematical study of the boundary integral equation method (BIEM) and engineering applications of the BEM has been developed more than 40 years. However, the equivalence of the solution space in the BIEM and the partial differential equation was not noticed. Degenerate scale, degenerate boundary [1], spurious eigenvalues and fictitious frequencies …etc. only occurring in the BEM instead of the FEM indicate that the equivalence check is very important. Here, we focus on the degenerate boundary.

In 1956, Kinoshita and Mura [2] derived the singular boundary integral equation for elasticity. Later, the BEM, or sometimes called the BIEM, has been numerically implemented since Rizzo [3] discretized the integral equation for elastostatics in 1967. Over twenty years, the main applications were limited in boundary value problems (BVPs) without a degenerate boundary. The key reason is that a degenerate boundary may cause rank deficiency of the influence matrices in the conventional BEM. However, engineering problems containing degenerate boundaries are always present, e.g., a cracked bar under torsion. Traditionally, the multi-domain BEM was presented to solve the nonunique solution by introducing an artificial boundary in the past two decades (1960-1988). In other words, we must decompose the domain to sub-domains for solving this kind of problems [4]. Nevertheless, the main spirit and merit of the BEM is that we only need to discretize the real boundary of the problem. Obviously, domain decomposition of problems lose the benefit and disobey the main goal of BEM. In order to solve problems containing a degenerate boundary in a single domain, e.g., crack problems, Hong and Chen [5] presented the dual boundary integral equations to solve crack problems, and the dual integral formulations have been numerically verified in many fields. By using the dual integral formulation, the problems containing a degenerate boundary can be efficiently solved in a single domain.

Although torsion problem of a cracked bar [6] have been studied by using the dual BEM, they did not examine the SVD structures of influence matrices in the dual BEM to the authors' best knowledge. Following the successful experience on the retrieval of information using SVD updating term and updating document [7], we will revisit the dual BEM. By employing SVD with respect to the four influence matrices in the dual BEM, the roles in the right and left singular vectors are examined. It was discovered that the physical information due to the rigid-body mode is found in the right singular vector, and the mathematical information

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